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ABSTRACT

Data from experiments with high school chemistry students revealed (1) that remediation positively influences cognitive achievement and retention, and (2) recycling, which introduces alternate materials and activities under teacher direction, provides more optimum learning conditions than repeating the learning activities and reviewing the reading materials previously encountered. The investigation involved a chemistry learning sequence with 53 eleventh- and twelth-grade students for which tests were administered to measure both progress during the sequence and achievement and retention after the sequence. One of three types of remedial work was prescribed for those achieving less than mastery. Group one received treatment modeled after the Learning-for-Mastery System (small group study, peer tutoring, self study, discussions with the teacher). Group two received Personalized System of Instruction remediation (repeating reading and problem assignments, review notes, and laboratory reports). Group three received no further instruction on the objectives but was given optional assignments to improve grade level. An unannounced, delayed-achievement posttest was given 13 weeks later to elicit the retention data upon which the report was based. (MB)

A COMPARISON OF REMEDIATION SYSTEMS AFFECTING ACHIEVEMENT AND RETENTION IN MASTERY LEARNING

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ABSTRACT

This investigation sought to compare the influence of different remediation strategies on cognitive achievement and retention of high school chemistry students. Given this purpose, the design necessitated a common instructional phase followed by a remediation period (treatment). Fifty-three students were randomly assigned to one of three treatments. Eighteen days following the conclusion of the remediation phase an achievement post-test was administered to obtain the dependent variable data. Analyses of these data revealed that remediation does positively influence both cognitive achievement and retention. Moreover, recycling which include alternate materials and activities appears to provide more optimum learning conditions than repeating the learning activities and reviewing the reading materials encountered during the initial instruction of a unit.

Simply stated, mastery learning consists of a learner attaining "passing" scores on a criterion referenced test with respect to stated performance objectives. The criterion values stated in the objectives usually vary with the instructor and course, but levels of performance ranging between 80 and 100 percent appear to be most common (Block, 1970). Instructionally, the unique feature of a mastery strategy is recycling, learners are provided additional opportunities to achieve higher performance scores on retests without being penalized by an initial poor performance.

Two mastery strategies, learning-for-mastery (Bloom, 1968) and Personalized System of Instruction, (Keller, 1968) have evolved independently yet concurrently. Both embrace the concept of recycling and the model of learning developed by Carroll. This model is based on the idea that learning is a function of five primary factors: (1) aptitude (time necessary for a student to learn a task; (2) perserverance (time a student will spend on a task); (3) opportunity to learn (time for learning); (4) quality of instruction; and, (5) student ability to understand instruction (Carroll, 1963). Another similarity between these mastery learning strategies is the high degree of student success resulting in negatively skewed distribution curves for learning that demonstrate greater cognitive learning. Documentation of this generalization abounds for the Personalized System of Instruction (Keller, 1968, McMichael and Corey, 1969; Koen, 1970; Hoberock, 1971; Born, Gledhill, and Davis, 1972; Leo, 1973; Austin and Gilbert, 1973; Corey and McMichael, 1974; McKean, Newman and Purtle, 1974; Jones, 1976) as well as the learning - for - mastery paradigm (Collins, 1972; Block, 1972; Sheldon, Stephen, and Miller, 1973; Wagner and Jones, 1973; Wentling, 1973; Denton and Gies, 1975; Poggio and

Glasnapp, 1976). A number of these investigations also report a corresponding increase in retention as well as cognitive achievement. Although there are many similarities between these mastery approaches, a number of differences do exist. These differences delineated by Block (1974) are presented in figure 1.

Figure 1

A plethora of research and testimonials has been reported on the impact of mastery learning strategies on student achievement. An investigation by Fehlen (1973) which compared the use of diagnostic progress tests with tutorial remediation help is unique in that Fehlen directly compared aspects of Personalized System of Instruction with Learning for Mastery. This work has signaled an important area for research on mastery learning, that is, comparing the efficacy of different mastery strategies on cognitive learning.

Given the state of the literature on mastery learning and its potential for affecting student achievement, this investigation was designed to compare remediation strategies of two mastery learning approaches. Specifically, this investigation sought to determine (1) whether different remediation strategies result in differences in cognitive achievement measured by the number of objectives achieved and (2) cognitive retention measured by posttest achievement scores of high school chemistry students.

Method

Sample

Learners participating in this investigation were 11th and 12th grade students enrolled in chemistry in a public high school in central New York State. This high school is situated in a school district that serves approximately 2900 learners with nearly 900 students in grades nine through twelve. The sample consisted of 53 students enrolled in chemistry during

the 1974-1975 school year. These learners, enrolled in two afternoon classes, were randomly assigned to one of three remediation treatment groups.

Instrumentation

The achievement instruments used in this investigation were developed from multiple choice items obtained from previous New York State Regents' examinations in chemistry. Eighty questions were selected from these examinations and categorized into five subsets (15 items/subset) which are directly referenced to the objectives in unit 6 of the New York Regents' Syllabus for Chemistry (1966). This unit examines the topics of "kinematics" and "equilibrium" discussed in Chapter 15 of Chemistry: A Modern Course (Smoot, Price, and Barrett, 1968) and experiments 27 and 28 of Laboratory Chemistry (Carmichael, Haines, and Smoot, 1971).

Two 25 item instruments were developed by random selection of questions from the 80 item pool. One instrument termed the formative achievement test was used during the investigation to monitor learner progress toward achieving the performance objectives of the unit. The second instrument was designated as the achievement posttest from which the achievement and retention data were obtained. The internal consistency estimate (.791) was determined with the Kuder-Richardson Formula 20 for the achievement posttest. Content validity of this test was checked by matching the selected items with the five performance objectives of the instructional unit and submitting the resulting objective-test items sets to a panel of high school chemistry teachers for review. The panel examined the test items to determine whether the selected questions measured the intellectual skills indentified in the performance objectives and subsequently endorsed the tests to measure those objectives.

Treatment

A mastery learning orientation phase was implemented nearly four months prior to the experimental phase. During this period, students learned how to use: performance objectives, formative test results, remediation procedures, group and individual tutorial sessions, and review sessions. This orientation reduced the potential of a Hawthorn effect and enhanced the transition of the groups into the experimental phase of the investigation. It was therefore possible to organize the experimental groups and commence the experimental phase of the investigation without altering the instructional environment.

All students experienced a common treatment which preceded the experimental treatments namely, three remediation strategies. On the first day of the instructional phase all students were given five performance objectives related to Chapter 15 of Chemistry: A Modern Course (Smoot, Price and Barrett, 1968). Instruction on these objectives was conducted over 11 class periods of 45 minute duration and two 90 minute laboratory periods. The laboratory periods were used to complete two experiments from Laboratory Chemistry (Carmichael, Haines, and Smoot, 1971) entitled "Reaction Rates" and "A Study of Chemical Equilibrium." Laboratory reports were submitted to the instructor, evaluated and returned. In addition, one problem assignment on reaction rate and equilibrium calculation was remitted and two brief formative progress tests were administered to the students. The conclusion of this treatment component was signaled by the administration of the achievement posttest.

At this point, the achievement posttests were scored and feedback (knowledge of performance) was provided to the students. Depending on group assignment, one of the following three remediation strategies was required if the learner's performance was less than mastery as prescribed by the performance objectives.

1. Remediation strategy (LFM). This experimental treatment was modeled after the Learning-for Mastery System. Students were provided class time to engage in: a small group using knowledge of the achievement posttest results, peer tutoring, self-study, and discussions with the teacher. Students in this group requested the formative achievement test when they felt confident they could succeed. Students not succeeding on this attempt were required to attend a special review session with the instructor, scheduled outside of class time. This subsequent teacher directed activity was followed by the readministration of the formative achievement test. The second administration of this test or the expiration of 5 class days marked the conclusion of the remediation treatment.
2. Remediation Strategy (PSI). This remediation strategy was designed to model the Personalized System of Instruction. Learners who did not reach mastery on the achievement posttest were given instructions to repeat the reading assignments, and study the original problem assignments and laboratory reports. In addition, students in this group were encouraged to review the class notes taken during instruction which preceded the achievement posttest. When the learner felt prepared, he requested to be evaluated with the formative achievement test. Given knowledge of the results of this test, unsuccessful learners were provided a second opportunity to take the formative achievement test, but remediation using the original materials was left up to the student. This remediation strategy was also concluded after 5 class periods or two administrations of the formative achievement test.

3. Remediation Strategy (Control). The control or non-mastery treatment group members received no additional instruction on the unit objectives following the achievement posttest, but they were given an optional assignment to improve their course grade and to enhance their understanding of the unit objectives using class time. Students in this group were instructed to use the library or other sources to research two of the following five topics:

    1. Haber Process
    2. Ostwald Process
    3. Solvay Process
    4. Contact Process
    5. Process of obtaining pure Mg from sea water.

    Additional directions required the student to include the basic chemical equations describing the selected processes and comment on reaction rate effects, equilibrium conditions involved, effects of Le Chatellier's Principle on the reactions, and the optimum reaction conditions for those processes selected. As with the other remediation strategies, the allotted time for this assignment was five class periods.

Although the conclusion of the remediation strategies marked the end of instruction devoted to the topics of kinematics and equilibrium, the investigation was not concluded until the achievement posttest was readministered 13 class periods later. The administration of this test was delayed and unannounced to qualify the resulting information as retention data.

Results and Discussion

Comparison of treatment group values obtained from the initial administration of the achievement posttest was made to determine group equivalence.

The resulting F value (.624 P.50) clearly indicates the equivalence of the 3 groups prior to remediation, with respect to the cognitive skills under consideration. As expected from the F ratio, the mean and standard deviation values for the PSI group ($\bar{X}$ = 14.06, S.D. = 3.62), LFM group ($\bar{X}$ = 15.59, S.D. = 3.22), and Control group ($\bar{X}$ = 13.89, S.D. = 3.79) were nearly equivalent.

The issues under consideration in this investigation were the influence of different remediation strategies on cognitive achievement and retention. Results from the second administration of the achievement posttest were used to resolve both achievement and retention issues. For this investigation, cognitive achievement was defined in terms of the number of performance objectives accomplished. The achievement posttest was developed as a criterion referenced test containing five subsets of test items with each subset being relative to one of the performance objectives in the instructional unit. While the test items were selected randomly from an item pool, the number of questions for each objective were not equal. Table 1 provides the number of questions and criterion level for each objective. Attainment of the five objectives was determined for each student by scoring each subset of test items.

Table 1

A 2 x 3 contingency table was used to test the significance of the number of objectives achieved by students in the three treatment groups. Of the 90 objectives possible for the PSI treatment groups, 53 were successfully achieved and 37 were not achieved. Of the 90 objectives possible for the Control treatment group, 39 were successfully achieved and 51 were not achieved. In the LFM treatment group, 85 objectives were possible for attainment; 61 were successfully achieved while 24 were

not achieved. The resulting Chi-Square value was calculated to be 14.56 P.001.

Additional analyses were conducted to determine which of the three interactions would result in a significant Chi-square value. The resulting Chi-square for the PSI group and control group was 4.36 (P.034) while the control group--LFM group comparison yielded a Chi-square value of 14.43 (P.0004). A comparison of the mastery strategies, i.e., PSI group --LFM group, produced a Chi-square of 3.19 (p.07). Table 2 provides a summary of the various comparisons made to determine the influence of the remediation strategies on objective attainment.

Table 2

These results are consistent with the investigation of Denton and Gies (1975) and indicate students undergoing remediation accomplish a greater number of objectives than students participating in an instructional program that does not include remediation activities. Not only does the occurrence of remediation influence attainment of objectives, these results suggest the nature of the remediation activities affects objective attainment as well. Remediation activities which provide alternate materials and instructional modes under the guidance of the teacher appear to be superior to a student-centered approach that encourages rereading and reviewing the materials used during initial instruction.

Retention of cognitive skills was defined in this investigation as the total score achieved by the student on the second administration of the achievement posttest. This value served as the dependent variable with the remediation strategies representing the independent variable. An analysis of variance procedure produced and F ratio of 3.95 (P.025) when the retention values were compared. A summary of this procedure

is presented in Table 3.

Table 3

Since this analysis produced a significant F ratio, additional analyses were performed using a t-test of difference between means for the three treatment groups. (Nil, Hull, Jenkins, Steinbrenner, & Bent, 1975). The comparisons produced the following results: LFM--Control (t=2.83 P.008), PSI--Control (t=1.36 P.183), PSI--LFM (t=1.50, p.142). The results of the LFM--Control comparison are consistent with the literature, namely, Block, 1972; Wentling, 1973; while the results of the PSI--Control analysis are not in total agreement with the findings reported by Corey and McMichael (1974) since the t value was not significant. Unfortunately, the assessment of mastery strategies (PSI--LFM) on retention has no analog in the literature reviewed. Consequently, the non-significant finding in this investigation must await validation comparisons until additional research is reported. In general, the results of this investigation suggest that remediation strategies positively influence retention.

Conclusions and Implications

This investigation was conducted to compare different remediation systems with respect to student learning and retention in chemistry at the secondary school level. These issues have been resolved to the extent expressed in the following conclusions.

1. Achievement determined by the number of performance objectives mastered can be significantly increased by remediation strategies which emphasize accomplishment of the objectives. Moreover, remediation strategies which include alternate materials and activities appear to provide more optimum learning conditions than repeating the learning activities and reviewing the reading

materials encountered during the initial instruction of a unit.

2. Retention of cognitive skills, measured by a total score on an achievement posttest developed to assess student mastery of performance objectives, is influenced by the nature of the remediation strategy experienced by the student.

It is interesting to note that all treatments in this investigation produced increases in total scores on the achievement posttest as a result of implementing a remediation strategy following initial instruction and assessment. However, the additional time necessary for remediation may be considered as a drawback of this approach and mastery learning in general. The five days allotted for remediation in this investigation was very liberal. Both the Personalized System of Instruction (PSI) and Learning for Mastery (LFM) approaches suggest one or two additional days per instructional unit for remediation. It appears safe to state that the additional time for instruction pays dividends in student achievement and retention. Moreover, the results of this investigation suggest that a variety of approaches to remediation may be used but a teacher-directed approach appears to be most effective.

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Program Elements	Personalized System of Instruction (PSI)	Learning-For-Mastery (LFM)
Total Mastery	This system recommends perfect performance on a specified number of units within a given period of ti...	This system recommends performance at a high level on a final examination.
Learning Unit Length	The recommended length for an instructional unit is 1 week.	The recommended length for an instructional unit is 2 weeks.
Instructional Style	Instruction is individualized or student-paced with this approach.	Instruction is group-oriented or teacher-paced with this approach.
Instructional Mode	This system uses programmed materials and independent reading most frequently as instructional activities.	Independent reading, lectures, and class discussions play important roles with this approach.
Level of Performance for Mastery	This system recommends a 100% performance to demonstrate mastery.	This system recommends an 80%-90% performance for mastery.
Function of Unit Tests	Unit tests ... used to determine ... has or has not been ... d (test is used to ... ne mastery).	Unit tests provide diagnostic information on learner progress (test not used to determine mastery).
Remediation Strategies	This strat... sed tutors as the primary ... hod of corrective instruction ... conjunction with review ... the materials used prior to the ... it test.	A variety of learning activities and materials unlike those used before the unit test are recommended for remediation with this strategy.

Figure 1
Differences Between the Personalized System of Instruction and Learning-for-Mastery Systems.

Table 1

Objectives and Number of Questions Required for Mastery on Achievement Posttest

Objective	Number of Questions Related to Objectives	Questions required for Mastery	Percent Mastery
1	4	3 of 4	75.0
2	6	5 of 6	83.3
3	3	3 of 3	100.0
4	7	6 of 7	85.7
5	5	4 of 5	80.0

Table 2

Chi-Square Values and Frequency of Objectives Mastered and Not Mastered by Treatment Groups and by Pairs of Treatment Groups.

Group	Mastered	Not Mastered	Total Assigned
PSI	53	37	90
Control	39	51	90
LFM	61	24	85
Total	153	112	265
Chi-Square Value = 14.555			
Probability = .001			

Comparison of PSI-Control Groups

Group	Mastered	Not Mastered	Total Assigned
PSI	53	37	90
Control	39	51	90
Total	92	88	180
Chi-Square Value = 4.3577			
Probability = .034			

Comparison of LFM-Control Groups

Group	Mastered	Not Mastered	Total Assigned
LFM	61	24	85
Control	39	51	90
Total	100	75	175
Chi-Square Value = 14.429			
Probability = .0004			

Comparison of PSI LFM Groups

Group	Mastered	Not Mastered	Total Assigned
PSI	53	37	90
LFM	61	24	85
Total	114	61	175
Chi-Square Value = 3.1916			
Probability = .070			

Table 3

Descriptive Statistics and Analysis of Variance Summary of Three Remediation Strategies on Cog[illegible]ve P[illegible]

	Treatment Group		
	PSI	Control	LFM
N	18	18	17
$\bar{X}$	19.39	17.44	21.06
SD	3.88	4.67	2.49

Source	df	ss	ms	F	P
Between groups	2	114.64	57.32	3.95	.025
Within groups	50	725.67	14.51		
Total	52	840.31			